tilizer & Pesticide Best Management Practices

1994-8

Pesticides

Pesticides and Residues in Ground Water and Surface Water Environments

Pesticides are valuable tools in agriculture and in maintaining our home, lawns and gardens in Montana. Pesticides protect crops and livestock from insect attack, minimize competition from weeds and reduce disease incidence. Unfortunately, when a pesticide is put down incorrectly, it doesn't always stay put. Pesticide use and/or misuse may lead to water quality problems. Pesticides can leach with water through the soil, sometimes winding up in ground and surface water. Surface water can be highly susceptible to pesticide impairment from runoff and by impairment through ground and surface water interactions.

Pesticides can enter ground and surface water through:

- drift from spray application
- surface runoff (water and soil) from cropland
- irrigation return flow
- recharge of ground water
- improper mixing/loading procedures utilized at mixing/loading facilities
- applications to cropland
- improper storage facilities
- accidental spills

Agricultural activities, including irrigation of crops, conducted on land overlying shallow aquifers, can aid downward migration of salts, trace elements, pesticides and fertilizers until they reach ground water. The migration of a pesticide into water is dependent on the following: properties of the pesticide, rate and frequency of application, soil type, slope of field, type of crop, length of time between application and rainfall and whether a buffer zone that has no pesticides applied exists between cropland where these chemicals have been applied and surface water.

Methods that prevent pollution from pesticides should be implemented wherever pesticides are stored, applied and disposed. Once pesticides enter ground water they are difficult and expensive to remove. In some cases it is *impossible* to completely remove the contaminant from ground water.

Factors That Influence Pesticide Leaching

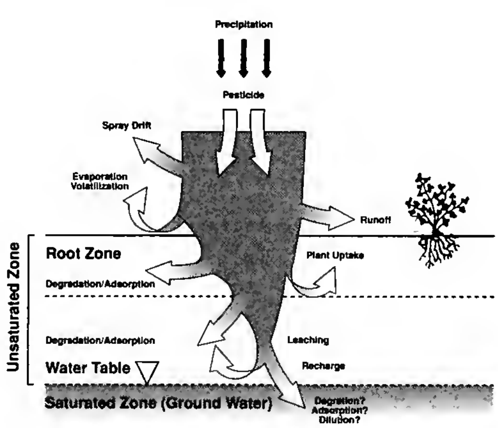
The potential for pesticides to enter ground and surface water exists wherever pesticides are used. The potential varies with the chemical properties of the pesticide, the soil and other factors such as volatilization (loss to the atmosphere), decomposition, soil adsorption and transport by water. Volatilization and decomposition reduce the total amount of pesticides available for downward movement. Soil adsorption decreases the availability of the pesticide for downward movement and transport by water. In addition, small quantities of pesticides are retained and removed from the soil by agricultural commodities.

Pesticide Properties

Solubility. *Solubility* is the ability of a pesticide to dissolve in water. As the solubility of a pesticide increases, there is a greater potential for transport to ground water (leachate). Pesticides with solubilities below 30 parts per million (ppm) are considered to have relatively low potentials for leaching. If the solubility is one ppm or less, the product will tend to remain at the soil surface, but may move off-site with soil sediment. The solubility of a pesticide tends to decrease with an increase in dissolved salts and increase in the presence of dissolved organic matter.

Persistence. The *persistence* of a pesticide under a given set of conditions is expressed in terms of the length of time required for 50 percent of the pesticide to decompose to products other than the original pesticide. This is referred to as the half-life ($T_{1/2}$) of the pesticide. The persistence of a pesticide is an important factor in evaluating its leaching potential. Pesticide persistence is categorized as non-persistent (half-life of 30 days or less), moderately persistent (half-life of 30 to 99 days), or persistent (half-life greater than 100 days).

Retention by soil. Retention of organic pesticides by soil particles is referred to as *adsorption.* Adsorption decreases the concentration of pesticides in solution (soil water) and thus decreases the availability for downward movement. Also, adsorption increases the length of time pesticides are available for decomposition by microorganisms in the biologically active surface soil. Pesticides are retained by soils to different degrees, depending on the properties of the pesticide, the soil and their interaction. The most important soil property that affects adsorption is organic matter content. The greater the organic matter content, the greater is the adsorption. Another important soil property influencing adsorption is clay content. The higher the clay content the higher the adsorption capacity of the soil.



Potential pathways of pesticide loss and transport (modified from McKenna, 1989).

Of all the pesticide properties, soil adsorption potential (Koc) plays the most significant role. A pesticide which has a low Koc value is susceptible to movement in solution through the soil

MONTANA STATE UNIVERSITY
1893•CENTENNIAL•1993
Extension Service

profile and into ground water. However, if the $T_{1/2}$ is also low, the potential for movement is lessened due to rapid degradation of the pesticide.

Pesticide Fate

Hydrolysis. Some pesticides react with water *(hydrolysis)* in soil to form new compounds. The rate of this process varies with the soil pH. Pesticides can hydrolyze to form new compounds which may have pesticidal properties or be rendered inactive.

Volatilization. Pesticides that are *volatile* (high vapor pressures) and have low water solubility tend to be readily vaporized or converted to a gas and lost from the soil to the atmosphere. They are unlikely to be transported into the soil. Pesticides that are volatile and readily vaporized are generally substances, such as fumigants, which allow for the pesticide to move readily throughout the material to be fumigated (insecticides can also be fumigants). Generally, fumigants are more volatile than insecticides and insecticides are more volatile than herbicides. Air temperatures also play a major role in controlling volatilization.

Decomposition. Sunlight breaks down organic compounds. This process is referred to as *photodecomposition.* Most herbicides, insecticides and fungicides are decomposed to some extent by sunlight. The photodecomposition rate of pesticides in surface water is dependent mainly on the intensity of the sunlight and the depth of the contaminant within the body of water. Photodecomposition may have little practical significance for pesticides located below the surface. Organic pesticides applied to plants or soil may lose effectiveness from photodecomposition, whereas those incorporated into the soil are protected.

Microorganisms. Pesticide decomposition in soil is carried out mainly by *microorganisms* and to a smaller extent by plants. Fertile soils contain millions of microorganisms per ounce of surface soil. Pesticides can serve as sources of nutrients and energy for microorganisms. The rate of microbiological breakdown of pesticides varies with the pesticide chemical structure, pesticide concentration, soil moisture, soil temperature, organic matter, pH, nutrients, soil fertility, availability of microbial population and plant cover. Rapid degradation of pesticides in soils is one of the major reasons certain pesticides that exhibit mobility have not been detected in ground water.

Rate and Frequency of Application

The application rate of a pesticide will greatly affect the likelihood that a pesticide will reach ground water. Some of the newer pesticides can be applied at very low rates, decreasing the risk. When selecting pesticides, be aware of the plant and animal life in your area, and take necessary precautions. In most cases, different pesticide formulations do not pose different risks to ground water.

Type of Crop

Close-growing crops will generally have less impairment potential than row crops because of the additional canopy. The vegetation tends to reduce soil detachment and filters out suspended organic materials from surface runoff. Deep-rooted crops tend to increase soil stability and increase infiltration. The longer the growing period of the crop and the more residue that is left on the field after harvest, the less soil erosion will occur. Certain cropping practices can also decrease the impairment potential of a given field by decreasing the need for application of pesticides. For example, resistant crop varieties can reduce pesticide application rates. Crop row alignment also affects the potential for runoff. Rows that run up and down the slope greatly increase runoff potential.

Soil Characteristics

Soil texture and permeability influence both water movement and water holding capacity. Water moves or percolates downward more rapidly through coarse, sandy soil than finer textured soils composed of silt, clay and organic matter. In addition to being less permeable, fine textured soils, generally with high organic matter, have greater water holding capacity and will adsorb or bind pesticides more readily than coarse textured ones. Pesticides in the root zone are available for plants and eventual degradation.

Runoff Losses

Runoff and related erosion occurs when water, moving over a sloping surface, picks up a contaminant, such as a pesticide, and empties into a lake, pond, stream or river. The amount of field-applied pesticide that leaves a field in the runoff and enters a stream primarily depends on the:

- intensity and duration of rainfall, and
- length of time between pesticide application and rainfall occurrence.

High rainfall or irrigated areas may have large amounts of water percolating through the soil. These areas with highly permeable soils are more susceptible to pesticide movement. Pesticide losses are largest when rainfall is intense and occurs shortly after pesticide application, a condition when water runoff and erosion losses are also greatest. In general, the amount of pesticide leaving a field in the runoff is small.

Prevention

After a pesticide reaches ground water, it may continue to break down, but usually at a much slower rate because the pesticide is not exposed to air and ultraviolet light. In addition, temperatures are cooler than on the soil surface and fewer microorganisms are present. Cleanup or decontamination of impaired ground water is difficult if not impossible. Prevention of ground water impairment is the best management strategy.

Heidi Hart, MSU Extension Assistant
Jeff Jacobsen, MSU Extension Soil Scientist

The programs of the Montana Extension Service are available to all people regardless of race, creed, color, sex or national origin.

Issued in furtherance of cooperative extension work in agriculture and home economics; acts of May 8 and June 30, 1914. In cooperation with the U.S. Department of Agriculture, Andrea Pagenkopf, Associate Vice Provost for Outreach and Director Extension Service, Montana State University, Bozeman, Montana 59717.

Funding provided by the Montana Agricultural Chemical Ground Water Protection Act and Fertilizer Checkoff. Additional information may be found in the General Agricultural Chemical Ground Water Management Plan (GMP).